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Reservoir Sediment Management Workshop for Tuttle Creek Lake and Perry Lake Reservoirs in the Kansas River Basin

by John Shelley

PURPOSE: This Coastal and Hydraulics Engineering Technical Note (CHETN) summarizes a brainstorming workshop/scoping session held on 5–6 August 2013 to conceptualize promising sediment management strategies to prolong the life of two, large, U.S. Army Corps of Engineers (USACE) reservoirs in the Kansas River basin in the state of Kansas within the U.S. Army Engineer District, Kansas City (NWK). The focus of the workshop was on ways to transport sediment from the reservoirs to the downstream channels, using concepts promoted by the USACE Regional Sediment Management (RSM) Program. This technical note describes the workshop format, lists ideas generated, and explains the options selected for further study.

INTRODUCTION: Sedimentation in USACE reservoirs decreases available storage and may have deleterious effects on the reservoirs' authorized purposes. Sedimentation problems are severe in reservoirs on the Kansas River, where expanding water demand due to population increases must be satisfied by storage volume that is shrinking due to decades of ongoing reservoir sedimentation. Correspondingly, downstream channels are degrading, and sediment-dependent aquatic species are suffering from a lack of sediment. The workshop was held to develop sediment-management strategies to prolong the life of Tuttle Creek Lake and Perry Lake reservoirs in the Kansas River basin (Figure 1).

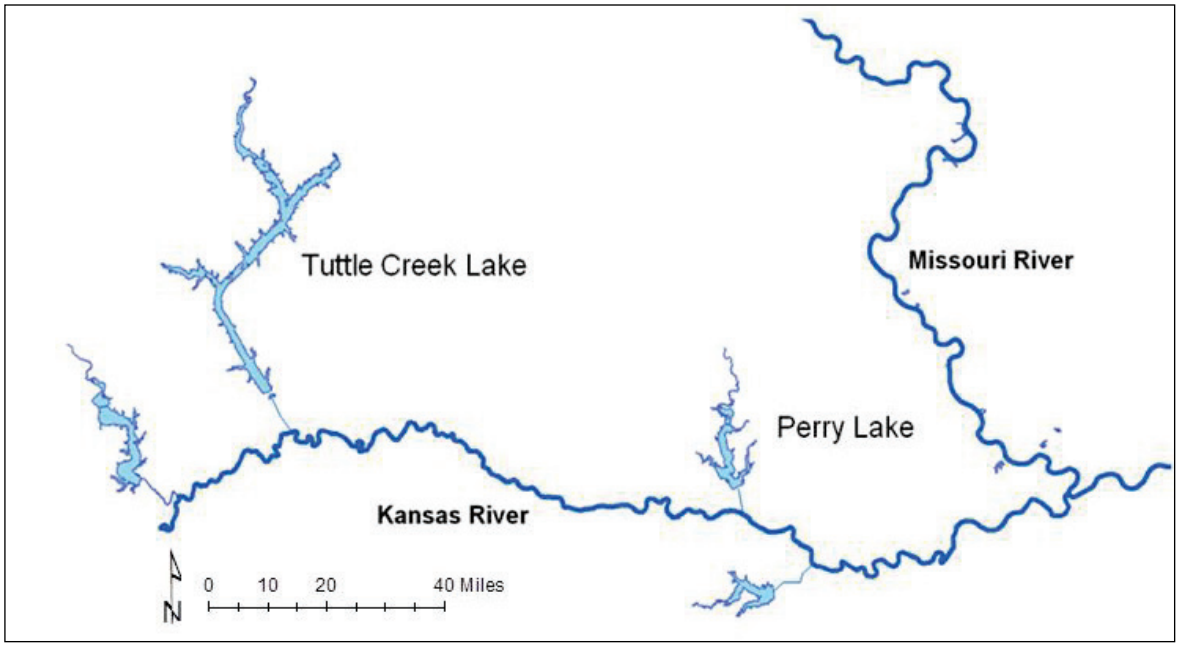

Figure 1. Tuttle Creek Lake and Perry Lake Reservoirs, Kansas.

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The workshop included robust participation by six State of Kansas agencies including agencies responsible for water and natural resources planning, research, and permitting. Other participants included watershed protection groups, U.S. Geological Survey (USGS), and USACE personnel from NWK, Omaha District (NWO), Tulsa District (SWT), U.S. Army Engineer Research and Development Center (ERDC), and USACE Institute for Water Resources, Hydrologic Engineering Center (HEC). Also in attendance were two internationally recognized reservoir sedimentation experts, Dr. George Annandale, Golder Associates, Denver, CO, and Dr. Rollin Hotchkiss, Brigham Young University, Provo, UT.

WORKSHOP FORMAT AND PREPARATION: The workshop format followed the basic, creative problem-solving paradigm advocated by Roger von Oech (1986), wherein the creative process is divided into four tasks: 1) data gathering, 2) idea generation, 3) idea evaluation, and 4) implementation. Workshop attendees participated in each of these tasks over the course of 2 days, as explained below.

Prior to the workshop, a *data book* for each reservoir was developed. These data books included tables, maps, and graphs on the hydrology, watershed characteristics, locations, and magnitude of in-reservoir sedimentation, sediment physical and chemical characteristics, outlet works, and downstream channel geomorphology. These data books were sent to workshop participants in advance of the workshop to establish a common understanding of the specific reservoirs. Presentations on the first morning included a review of the information provided in the data books, and two presentations by reservoir sedimentation experts Dr. George Annandale and Dr. Rollin Hotchkiss. These experts highlighted the importance of reservoirs in meeting future water supply needs and presented case studies in sustainable sediment management at a number of reservoirs.

Following the morning presentations, participants generated ideas for reservoir sediment management in breakout groups. Participants were encouraged to generate ideas without regard to feasibility. Numerous ideas were generated that fell under the general categories of hydrosuction, flushing, dredging, watershed sediment management practices, operational changes, bypassing, trapping, dry excavation, reallocation, and no action.

Participants were asked to select the two or three ideas they considered *most promising* and to evaluate and refine the ideas for each reservoir. The most promising ideas at Tuttle Creek Lake included 1) operational changes to decrease trapping efficiency, 2) a mobile inlet extension pipe to increase the effectiveness of pressure flushing, and 3) water transfer between reservoirs to increase system redundancy and flexibility. The most promising ideas for Perry Lake included 1) hydrosuction with discharge to a downstream wetland or agricultural area, 2) a sediment bypass channel, and 3) a partial drawdown with dry excavation.

The second day began with a presentation from NWK Planning on USACE funding sources and authorities and a presentation from NWK Regulatory on regulatory considerations when discharging sediment into rivers. A breakout group was then held with participants organized by agency to discuss next steps and to determine who or what was missing from the workshop. Participants identified that the U.S. Environmental Protection Agency (USEPA) and the U.S. Fish and Wildlife Service (USFWS) could have provided meaningful perspectives if in attendance, and that their input should be sought early in the process of considering reservoir

sedimentation management approaches. USACE participants discussed how various ERDC programs could interface with the project effort.

IDEAS: Participants were arranged into three small groups for idea generation and categorization. Each group discussed *non-traditional* ideas to build on each other and brainstormed to identify solutions that would either 1) increase the life of the reservoir or 2) reduce impacts of sediment on the reservoir. Following the session, the groups met together, and the ideas were shuffled into several key topics. Representative ideas included the following:

1. Hydrosuction

    - Hydrosuction over spillway – potentially extend sediment discharge pipe to the Kansas River.

    - Sediment bypass with dredging – vary rates of sediment loading for regulatory requirements using sediment injection ports.

    - Hydrosuction downstream of dam (Perry Lake) into agricultural area, with appropriate permits and authorization. Rotate the fields that are flooded.

2. Flushing/Sluicing

    - In-reservoir revetment to divide reservoir into two halves. Sediment is directed into one half. Clean water flows over revetment and fills second half. Flushing scenarios focus on the half with sediment and are more effective because of decreased width.

    - In-reservoir structures to focus sediment towards the outlet.

    - Take advantage of inflow hydrograph timing differences between inflow hydrograph and Kansas River hydrograph crests.

3. Dredging

    - Perpetual Operation and Maintenance (O&M), beneficial uses.

    - Dredged material has multiple stakeholders. Determine if incentives exist such that the sediments (silt and sand) can be sold.

    - When dredging, use areas downstream of dam to temporarily store silt.

    - Begin dredging when reservoir function becomes seriously impaired by sediment accumulation and loss of storage.

4. Watershed Sediment Management Practices

    - Bank stabilization, grade control, and other in-stream measures to reduce inflow of sediment.

- Sediment management – land use controls for landowners in the county.

- Native grass buffer strips – 40-foot-wide border along all riparian areas and cropped fields adjacent to riparian areas. Fencing cattle out of critical riparian areas. Conservation easements. Alternative livestock watering.

- Wetland development in watershed.

5. Operational Measures

    - Operational adjustments to minimize lake discharge while upstream peak is entering.

    - Combine mechanical dredging/excavation at the upper ends of reservoirs (above causeways) with permanent management for heavy sediment, and create a flow management scheme during wet years to flush turbid density currents when it is feasible.

    - Begin flood water evacuation before the crest has completely arrived in the reservoir to take advantage of moving silt at the bottom.

6. Bypass

    - Bypass sediment from large flows through the reservoir via conduit.

7. Sediment Trapping and Dry Excavation

    - Inflatable upstream dams can be used to encourage floodplain inundation and drop out sediment in the floodplain.

    - Use upstream sediment traps such as low weirs to manage wetlands and control sediment pool vs. normal pool.

8. Pool Reallocation

    - Address unequal sediment deposition in flood pool vs. conservation pool.

9. No Action

    - Let reservoirs run their life cycle without actively managing reservoir sediments. Solicit public involvement prior to mandating any needed water use restrictions.

    - Reprioritize authorized purposes.

NEXT STEPS: In consultation with the Kansas Water Office, Tuttle Creek Lake was selected to begin technical evaluation of three promising ideas that are described below. The Kansas Water Office, established by the State legislature and governor, is the water planning, policy, coordination, and marketing agency for the state of Kansas.

Operational changes (altered timing of releases to decrease trapping efficiency). The first idea is to evaluate the operation of Tuttle Creek Lake to see if the timing of releases could be altered to decrease sediment trapping efficiency. Current operational procedure includes holding the complete inflowing hydrograph until after the storm and then releasing water. A potential option for decreasing trapping efficiency is to release water as soon as the peak of the flood on the Kansas River has passed. To evaluate the technical feasibility and effectiveness of this approach, an unsteady, one-dimensional (1D) flow and sediment model is presently planned. This model will include Tuttle Creek Lake reservoir, the Big Blue River, and the Kansas River, as shown in Figure 2.

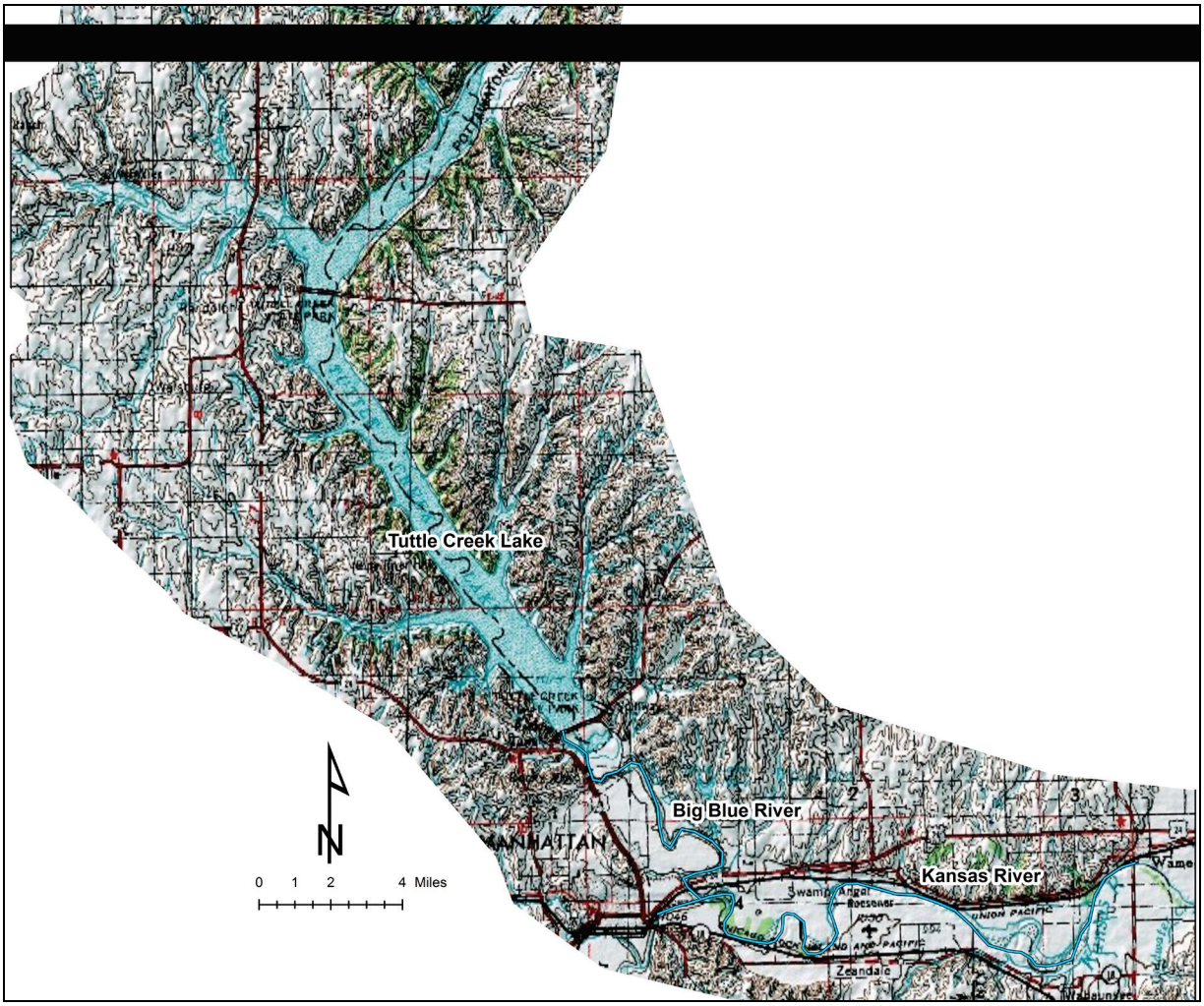

Figure 2. Proposed extent of 1D unsteady flow and sediment model.

The 1D flow and sediment model is adequate for feasibility-level assessment of many potential alternatives. The lateral distribution of sediment transport is important for other alternatives and for questions pertaining to ecological concerns; thus, a two-dimensional (2D) model may be considered for future studies.

Pressure flushing (using a moveable inlet extension pipe). The second idea is a unique adaptation of pressure flushing. In standard pressure flushing, low-level outlets are

opened to flush sediment through the dam. However, two obstacles preclude a typical implementation at Tuttle Creek Lake. First, Tuttle Creek Lake has no low-level outlets. Second, as pressure flushing only scours sediment from a narrow region around the reservoir side of the outlet, it is usually not effective for large reservoirs (Morris et al. 2008). The unique adaptation that will be evaluated is a movable inlet extension pipe. This could be a single pipe that connects to the existing inlet and extends to the reservoir bottom a short distance away. The zone of scour associated with pressure flushing will shift to the end of the extension pipe. The pipe can be moved from place to place in the reservoir or have multiple inlets or branches to access more sediment. This is illustrated in Figure 3.

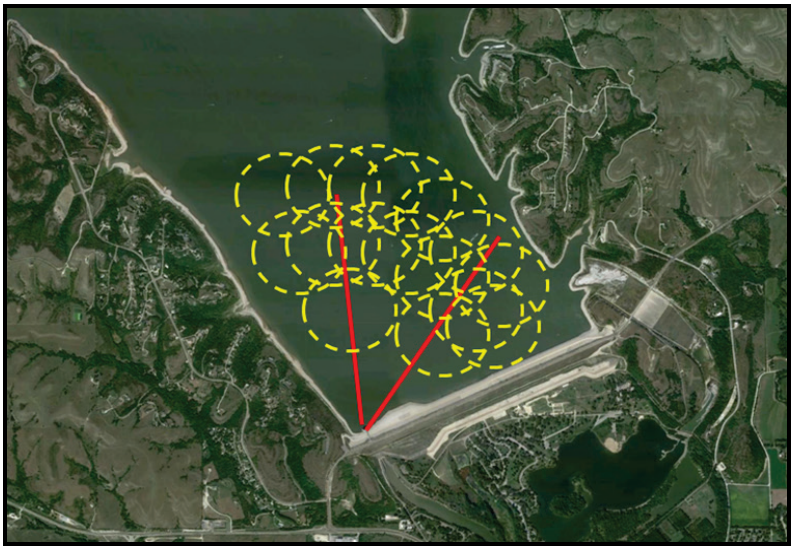

Figure 3. Hypothetical inlet extension pipe, Tuttle Creek Lake. Red lines indicate different locations of movable inlet extension pipe. Yellow circles represent zones of scour for different locations of inlet pipe.

Water transfer between Tuttle Creek Lake and Milford Lake. The third idea is a water transfer pipeline between Tuttle Creek Lake and neighboring Milford Lake (Figure 4). This represents a response to lessen the effects of sediment accumulation on water supply storage and is not a solution to sediment accumulation itself. Tuttle Creek Lake does not store as much water as it did prior to decades of sediment accumulation. Neighboring Milford Lake could offer more supply yield with increased inflow. A technique to evaluate this approach is to perform a water budget assessment of whether the water that is no longer stored due to sediment accumulation at Tuttle Creek Lake could be used to increase supply yield at Milford Lake.

In addition to an analysis of these three ideas, follow-up meetings are anticipated to continue the momentum of the first meeting and to involve additional agencies in the process.

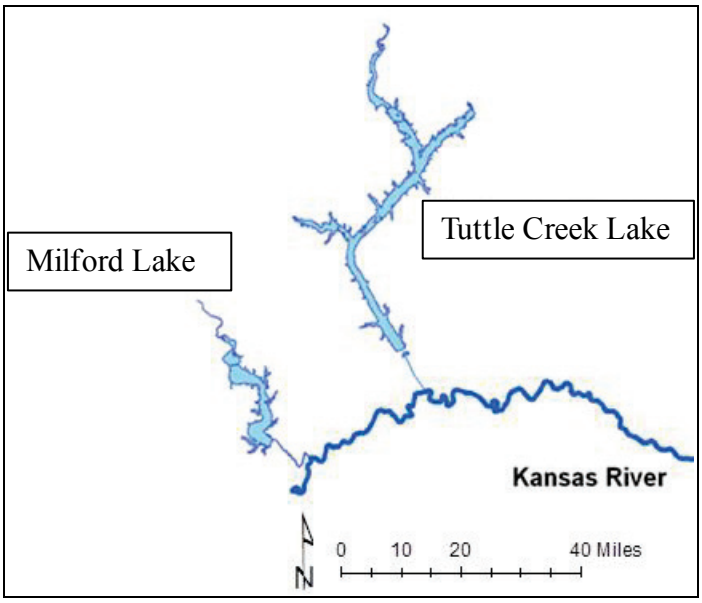

Figure 4. Milford Lake and Tuttle Creek Lake.

CONCLUSIONS: The brainstorming workshop/scoping session held 5–6 August 2013 was highly successful in bringing the appropriate people together to begin addressing the reservoir sedimentation problem at USACE reservoirs in Kansas. The success of the workshop hinged on the compilation of the databooks, broad participation by the technical, regulatory, and planning agencies, a well-defined plan for breakout sessions, and presentations and participation by technical experts with experience in successful reservoir sediment management. Of the many ideas generated, the three selected for further technical analysis at this time were

1. operational changes (altered timing of releases to decrease trapping efficiency)
2. pressure flushing (using a moveable inlet extension pipe)
3. water transfer between Tuttle Creek Lake and Milford Lake.

ADDITIONAL INFORMATION: This Coastal and Hydraulics Engineering Technical Note (CHETN) was prepared as part of the USACE Regional Sediment Management (RSM) Program by John Shelley of the U.S. Army Engineer District, Kansas City (NWK). Additional information regarding RSM can be found at the Regional Sediment Management website *http://rsm.usace.army.mil*.

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